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(71) Applicant: **CANON KABUSHIKI KAISHA**
30-2, 3-chome, Shimomaruko, Ohta-ku
Tokyo(JP)

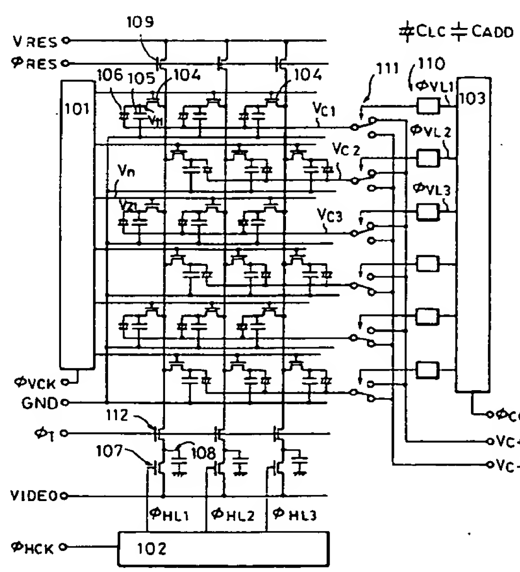
(72) Inventor: **Ishizaki, Akira**
c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko
Ohta-ku, Tokyo(JP)
Inventor: **Sugawa, Shigetoshi**
c/o Canon Kabushiki Kaisha, 3-30-2, Shimomaruko
Ohta-ku, Tokyo(JP)

(74) Representative: **Tiedtke, Harro, Dipl.-Ing. et al**
Patentanwaltsbüro, Tiedtke-Bühling-Kinne & Partner, Bavariaring 4
D-80336 München (DE)

(54) **Liquid crystal display.**

(57) A liquid crystal display includes a liquid crystal sealed in a space between a pair of substrates through the intermediary of a spacer, and electrodes provided on the substrates for applying voltages between selected electrodes on one of the substrates and corresponding ones on the other so as to control the orientation of the liquid crystal in order to effect displays. While one of the substrates is an active-matrix substrate on which pixel electrodes are disposed in a matrix pattern with a transistor being disposed for each pixel electrode, the other substrate supports thereon both opposite electrodes divided into sections parallel with scanning lines and a potential controlling device for controlling the potential of the opposite electrodes. Since the opposite electrodes are inverted and driven by the potential controlling device on the same substrate as the opposite electrodes, power consumption can be decreased while the number of wiring elements between the substrates is decreased to improve reliability.

FIG. 1



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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a liquid crystal display for displaying images and the like.

Related Background Art

Liquid crystal displays (LCDs) for displaying images by utilizing the orientation of liquid crystals have been applied to various uses. In earlier days, LCDs came into use in watches, desk-top electronic calculators, etc. to display relatively simple figures and symbols. In recent years, LCDs have come into use in televisions, etc. to display high-definition images. One particular advantage of the use of a liquid crystal display is that it is possible to reduce the thickness of a screen. Hence, portable televisions and like small apparatuses are regarded as a promising use.

One of the primary requirements of a movable apparatus, such as a portable television, is that the apparatus must be light. It is often the case with an electrical apparatus that the weight of the power source, such as a battery, for driving the apparatus amounts to a large proportion of the total weight. Thus, it is very important for such an apparatus to have the lowest possible level of power consumption, and be able to operate for a long period of time with a small-capacity power source.

However, in a conventional liquid crystal display using a twisted nematic (TN) liquid crystal, it has been a common practice to invert the potential applied to pixels per predetermined period of time in order to prevent an inherent phenomenon of liquid crystal panels, i.e., a phenomenon known as "sticking", and thus to improve reliability. A TN liquid crystal is generally driven at a voltage level of 0 to 5 V. Accordingly, in order to effect such an inversion, it is necessary to additionally apply ± 5 V, that is, to supply a signal having an amplitude of 10 V, to common electrodes at a fixed potential. Thus, at every inversion, the power consumption is twice the level as at other times. Means for overcoming this problem has been disclosed, for example, in Japanese Patent Laid-Open Nos. 58-49989 and 60-163091. Here, drive means inverts the potential of opposite electrodes to the positive or negative direction so as to halve the signal amplitude.

With the disclosed drive means, it is possible to decrease power consumption. However, the means for controlling the potential of the opposite electrodes comprises the same means that are provided on the same substrate as pixel electrodes in order to control the gates of transistors of a driving circuit. As a result, many wiring elements are necessary between the two substrates. This makes production processes complicated, and lowers the yield. In addition, the reliability of apparatuses may be impaired.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a liquid crystal display capable of overcoming the above-described problems.

Another object of the present invention is to provide a liquid crystal display having a low level of power consumption and yet is highly reliable.

A further object of the present invention is to provide a liquid crystal display comprising: a pair of substrates; a liquid crystal sealed in a space between the substrates through the intermediary of a spacer; and electrodes provided on the substrates for applying voltages between selected electrodes on one of the substrates and corresponding ones on the other substrate so as to control the orientation of the liquid crystal in order to effect displays, wherein one of the substrates comprises an active-matrix substrate on which pixel electrodes are disposed in a matrix pattern and on which a transistor is disposed for each pixel electrode, and the other substrate supports thereon opposite electrodes and potential controlling means for controlling the potential of the opposite electrodes, the opposite electrodes being divided into sections parallel with scanning lines.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a circuit equivalent to a first embodiment of the present invention;

Fig. 2 is a timing chart showing the operation of the first embodiment;

Fig. 3 is another timing chart showing the operation of the first embodiment;

Fig. 4 shows a circuit equivalent to a second embodiment of the present invention;

Fig. 5 is a timing chart showing the operation of the second embodiment;

Fig. 6 is a sectional view of the essential parts of an embodiment of the present invention;

Figs. 7(a) and 7(b) are a plan view and a sectional view, respectively, of the relevant parts of a third embodiment of the present invention; and

Figs. 8(a) and 8(b) are a plan view and a sectional view, respectively, of the relevant parts of a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred form of a liquid crystal display according to the present invention is as follows:

A liquid crystal display includes a liquid crystal sealed in a space between a pair of substrates through the intermediary of a spacer, and electrodes are provided on the substrates for applying voltages between selected electrodes on one of the substrates and corresponding electrodes on the other substrate so as to control the orientation of the liquid crystal in order to effect displays of image signals. One of the substrates is an active-matrix substrate on which pixel electrodes are disposed in a matrix pattern and on which a transistor is disposed for each pixel electrode. On the other substrate, opposite electrodes and potential controlling means for controlling the potential of the opposite electrodes are provided, the opposite electrodes being divided into sections parallel with scanning lines.

According to the present invention, potential controlling means for controlling the potential of opposite electrodes, specifically, a shift register, T flip-flops and voltage switching elements of each embodiment which will be described below, are provided on the same substrate as the opposite electrodes. Thus, the number of wiring elements between a pair of substrates is minimized. Further, the opposite electrodes are divided into sections parallel with scanning lines, and the potential of each opposite-electrode section is inverted per line or per frame. Thus, driving is possible with a power consumption level corresponding to the effective value, as in the conventional arrangement.

The type of potential controlling means and that of transistors provided for individual pixels, all according to the present invention, are not specifically limited. A bulk-transistor formed on a single-crystal Si substrate, which has been used in a reflection-type LCD, or a poly-crystal line or amorphous Si transistor for a transmission-type LCD, may be advantageously used, and a thin-film transistor (TFT) comprising a single-crystal Si thin film on a transparent substrate is preferably used. Regarding driving circuits for other capacitances, etc., the types and the forming methods which have conventionally been used may be employed.

Fig. 6 schematically shows a section of the essential parts of a liquid crystal display according to the present invention. The illustrated embodiment is a transmission-type liquid crystal display, in which switching elements comprise single-crystal Si transistors, and a driving circuit includes poly-crystalline Si transistors. Specifically, as shown in the drawing, the liquid crystal display has a liquid crystal layer 605 between an active-matrix substrate structure 609 and an opposite-electrode substrate structure 610. The active-matrix substrate structure 609 includes an insulating layer 601, transparent electrodes 602 for pixel capacitances, pixel electrodes 603, one of a pair of orientation control films 604 for aligning molecules of the liquid crystal, and single-crystal Si transistors 611. The opposite-electrode substrate structure 610 includes the other orientation control film 604', opposite electrodes 606 (divided into a plurality of sections only one of which is shown), poly-crystalline Si transistors 607, and a transparent substrate 608.

The present invention will now be specifically described with respect to embodiments thereof. However, the present invention is not intended to be limited by those embodiments.

Embodiment 1

Fig. 1 shows a circuit equivalent to a first embodiment of the present invention. The circuit includes a first shift register 101 for sequentially driving scanning lines, a second shift register 102 for driving each display line, and a third shift register 103 for driving opposite electrodes. The first and second shift registers 101 and 102 are provided on the same substrate as pixel electrodes, and the third shift register 103 is provided on the same substrate as the opposite electrodes. The circuit further includes a plurality of transistors 104 for switching the pixel electrodes, a plurality of pixel capacitance elements 105, and a plurality of liquid-crystal capacitance elements 106. Further, the circuit includes sampling transistors 107, sampling capacitance elements 108, resetting transistors 109, T flip-flops 110, voltage switching elements 111, and transfer transistors 112.

The operation of the first embodiment will be described with reference to a timing chart provided in Fig. 2.

The shift register 102 is actuated by a clock signal ϕ_{HCK} for determining the timing of the operation of sampling a video signal Video for pixels arranged in one of a plurality of horizontal rows (scanning lines), whereby the shift register 102 sequentially outputs pulses ϕ_{HL1}, ϕ_{HL2}, ϕ_{HL3} ... . In correspondence with the high-level period of these pulses, sampling transistors 107 are sequentially turned on, so that the video signal is sequentially stored in corresponding sampling capacitance elements 108. The above operation is repeated for one horizontal-row period (indicated by symbol "1H" in Figs. 2 and 3), so as to store the video signal for the particular scanning line in all the sampling capacitance elements 108.

The shift register 101 is actuated by applying each pulse of another clock signal ϕ_{VCK}, so that a gate voltage V_n connected to an n_{th} scanning line is brought to a high level thereof, thereby turning on corresponding transistors 104. The shift register 101 is constructed such that such transistors 104 are turned on for a period of time coinciding with a

period during which the clock signal ϕ_{VCK} is at a high level thereof.

During a period of time in which the gate voltage V_n is at its high level, the following two operations ① and ② take place one after another:

① A resetting signal ϕ_{RES} is brought to a high level thereof, thereby turning on resetting transistors 109, and thus bringing the potential of corresponding pixel capacitance elements 105, as well as liquid-crystal capacitance elements 106, to a level V_{RES}. Subsequently, the signal ϕ_{RES} is brought to its low level, thereby turning off the resetting transistors 109.

② Thereafter, a transfer signal ϕ_T is brought to a high level thereof, so as to write the one-line video signal Video, which has previously been stored in the sampling capacitance elements 108, to the corresponding pixel capacitance elements 105 and liquid-crystal capacitance elements 106 through the transistors 104 corresponding to the nth scanning line.

The above operations ① and ② are performed for each horizontal-row period, that is, repeated until all the scanning lines (pixel rows) are covered, thereby completing driving for one frame.

Fig. 3 is another timing chart showing potentials V_{C1} to V_{C3} of first to third sections of opposite electrodes, a video signal input Video, and a potential V_{11} of the pixel electrode in the first line on the first column.

The potentials V_{C1} to V_{C3} of the opposite-electrode sections are shifted from each other by one horizontal-row period, and are inverted per frame. The video signal Video is also inverted per frame in correspondence with the inversion of the opposite-electrode potentials. Thus, the potential V_{11} of the first-line first-column pixel electrode corresponds to the potential V_{C1} of the first opposite-electrode section. The potential (V_{C1} et seq.) of each section is inverted during a resetting period of the potential (V_{11} et seq.) of a certain pixel electrode.

Embodiment 2

Fig. 4 shows a circuit equivalent to a second embodiment of the present invention, and Fig. 5 is a timing chart showing the operation of the second embodiment. In the first embodiment, the potential of each opposite-electrode section is simply inverted per frame. In the second embodiment, however, the voltage switching elements 111 are connected in a different manner for every other scanning line so that the potential of an opposite-electrode section corresponding to the n_{th} line and the potential of another opposite-electrode section corresponding to the $n+1_{th}$ line are brought into opposite phases. Thus, in the second embodiment, driving is performed while the potentials of the opposite electrodes, etc. are inverted into an opposite phase line by line.

Embodiment 3

Figs. 7(a) and 7(b) show, in a plan view and a sectional view, respectively, the relevant parts of an embodiment in which a liquid crystal display includes metal electrodes provided on portions of opposite electrodes. The metal electrodes also serve as a light-shielding layer, whereby the embodiment is adapted for color displays.

Referring to these drawings, the liquid crystal display includes opposite electrodes 701, 701' which may be formed of a transparent indium-tin oxide (ITO) material. Metal electrodes 702, 702', which may be formed of a tungsten (W) or aluminum (A1) material, also serve as a light-shielding layer. The LCD further includes color filters 703, 703', insulating films 704, a glass substrate 705, and an orientation control film 706. In this embodiment, metal electrodes of a low resistivity are provided as auxiliary electrodes of opposite electrodes, and are able to serve as a light-shielding layer as well. Accordingly, it is possible to provide a color image with a blackened background, thereby allowing the image to sharply contrast with the background.

Embodiment 4

Figs. 8(a) and 8(b) show another embodiment in which, similarly to the third embodiment, metal electrodes are provided on portions of opposite electrodes to serve as both auxiliary electrodes and a light-shielding layer. A liquid crystal display according to the fourth embodiment includes opposite electrodes 801, 801', metal electrodes 802, 802', 802'', color filters 803, 803', insulating films 804, a glass substrate 805, and an orientation control film 806. The fourth embodiment is distinguished in that gaps between the opposite electrodes are completely shielded from light so as to achieve higher light-shielding effect than that provided by the third embodiment.

As has been described above, a liquid crystal display according to the present invention includes opposite electrodes divided into sections parallel with scanning lines. The opposite electrodes are inverted and driven by potential controlling means provided on the same substrate as the opposite electrodes. Accordingly, it is possible to decrease power consumption while the number of wiring elements between the substrates is decreased to improve the reliability of the apparatus. If metal electrodes are provided on portions of the opposite electrodes thus divided into sections, it is possible to improve the quality of color images, and to

reduce resistivity.

A liquid crystal display includes a liquid crystal sealed in a space between a pair of substrates through the intermediary of a spacer, and electrodes provided on the substrates for applying voltages between selected electrodes on one of the substrates and corresponding ones on the other so as to control the orientation of the liquid crystal in order to effect displays. While one of the substrates is an active-matrix substrate on which pixel electrodes are disposed in a matrix pattern with a transistor being disposed for each pixel electrode, the other substrate supports thereon both opposite electrodes divided into sections parallel with scanning lines and a potential controlling device for controlling the potential of the opposite electrodes. Since the opposite electrodes are inverted and driven by the potential controlling device on the same substrate as the opposite electrodes, power consumption can be decreased while the number of wiring elements between the substrates is decreased to improve reliability.

Claims

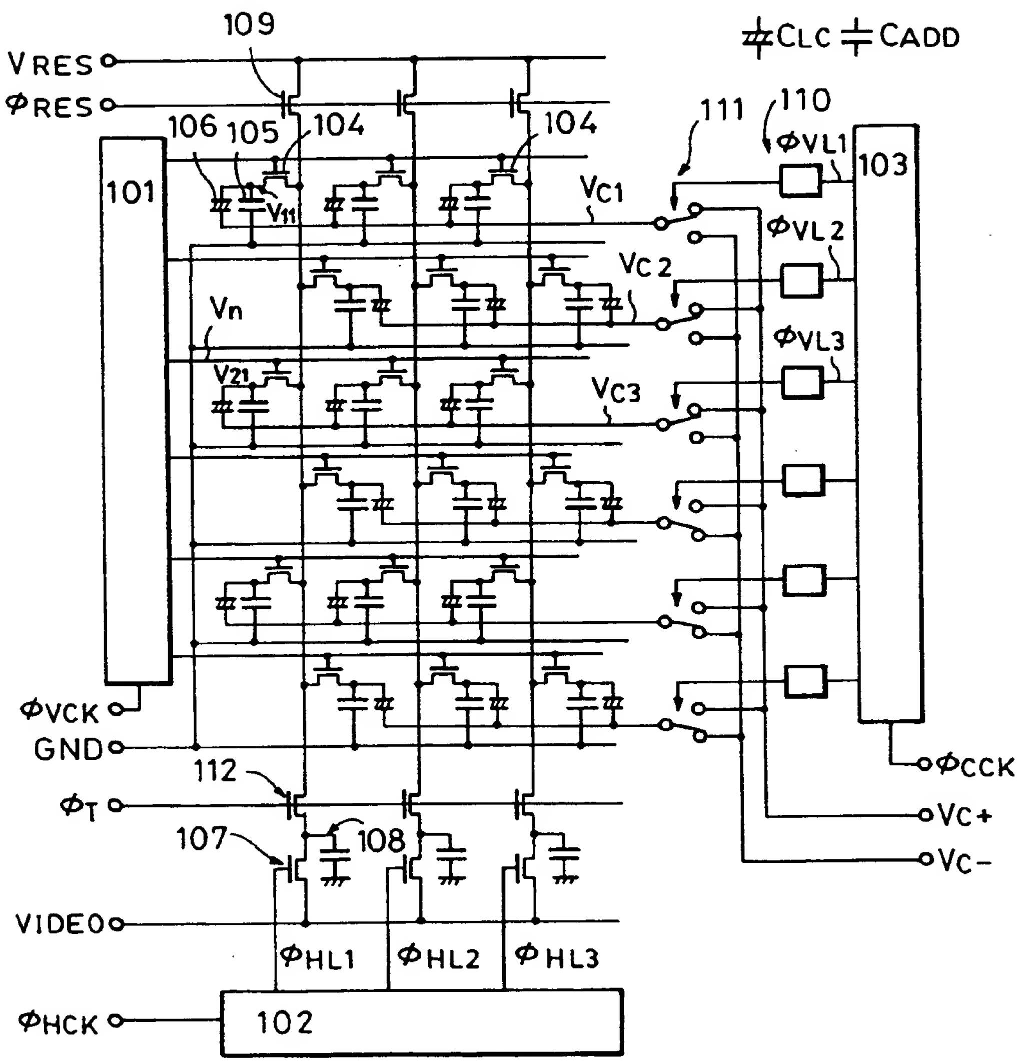
1. A liquid crystal display comprising: opposed first and second substrates spaced from one another by a spacer to create a space therebetween; a liquid crystal sealed in said space between said substrates created by said spacer; a first plurality of electrodes on said first substrate and a second plurality of electrodes on said second substrate, said electrodes being provided on said substrates for applying voltages between selected electrodes on one of said substrates and corresponding electrodes on the other substrate so as to control an orientation of said liquid crystal in order to effect displays of image signals, wherein one of said substrates comprises an active-matrix substrate on which pixel electrodes are disposed in a matrix pattern having a plurality of scanning lines and on which a transistor is disposed for each pixel electrode, and the other substrate supports thereon opposite electrodes and potential controlling means for controlling a potential of said opposite electrodes, said opposite electrodes being divided into sections parallel with said scanning lines.

2. A liquid crystal display according to claim 1, wherein an image signal to be displayed includes a plurality of frames and wherein a voltage applied to said opposite electrodes is inverted every frame.

3. A liquid crystal display according to claim 1, wherein an image signal to be displayed includes a plurality of frames and wherein a voltage applied to said pixel electrodes is inverted every frame.

4. A liquid crystal display according to claim 1, further comprising non-transparent electrodes provided on portions of said opposite electrodes to form a light-shielding layer.

FIG. 1


109
VRES
ΦRES
106
105
104
104
101
V11
Vc1
111
110
ΦVL1
103
ΦVL2
Vc 2
Vn
ΦVL3
V21
Vc3
CLC
CADD
ΦVCK
GND
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ΦCCK
Vc+
Vc-

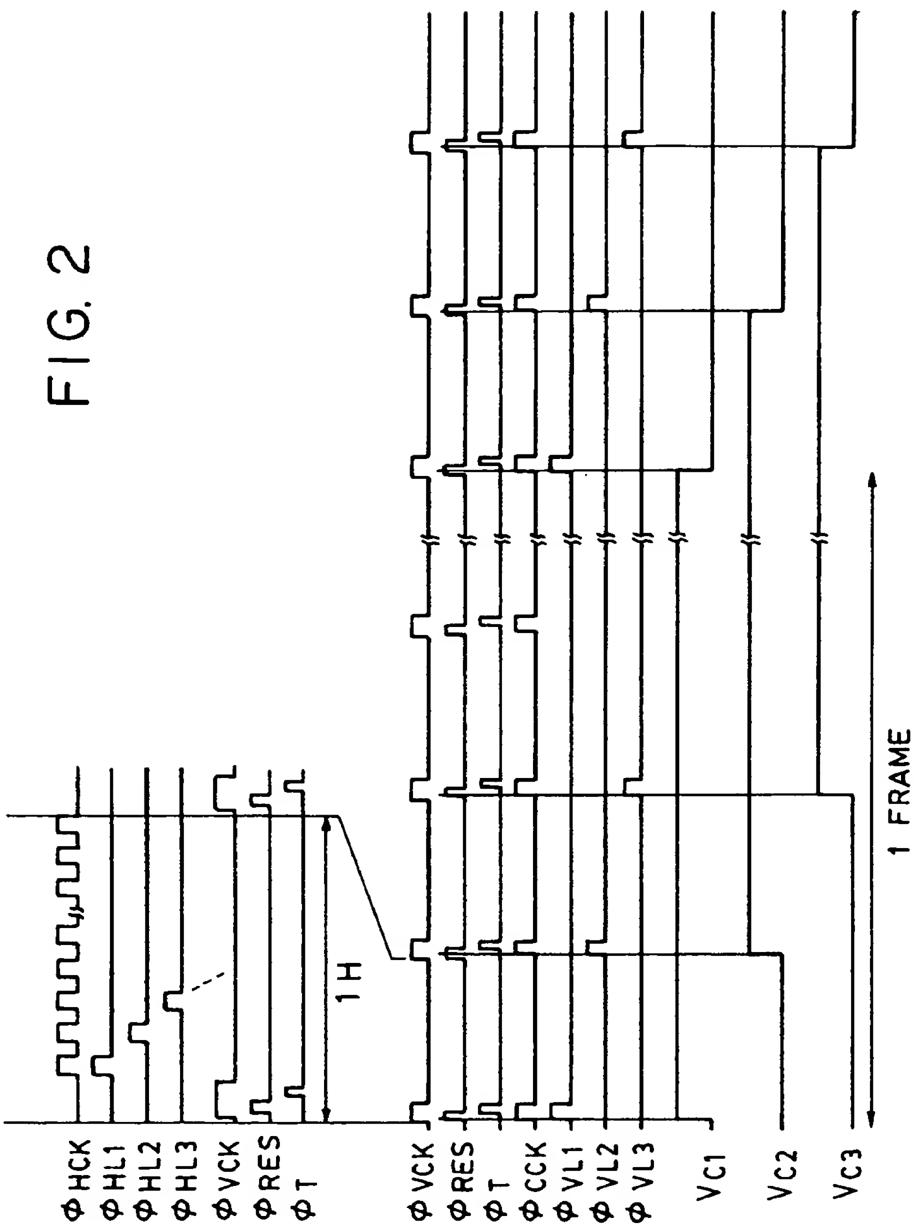
ΦHCK
ΦHL1
ΦHL2
ΦHL3
ΦVCK
ΦRES
ΦT
1H
ΦVCK
ΦRES
ΦT
ΦCCK
ΦVL1
ΦVL2
ΦVL3
VC1
VC2
VC3
1 FRAME

FIG. 2

FIG. 3

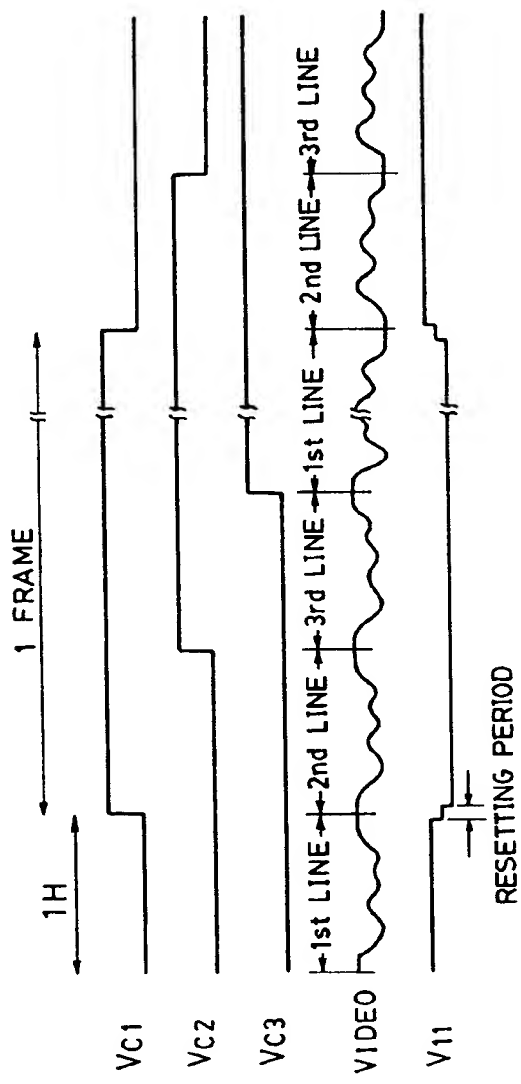
1 FRAME
1H
Vc1
Vc2
Vc3
VIDEO
V11
1st LINE
2nd LINE
3rd LINE
1st LINE
2nd LINE
3rd LINE
RESETTING PERIOD

FIG. 4

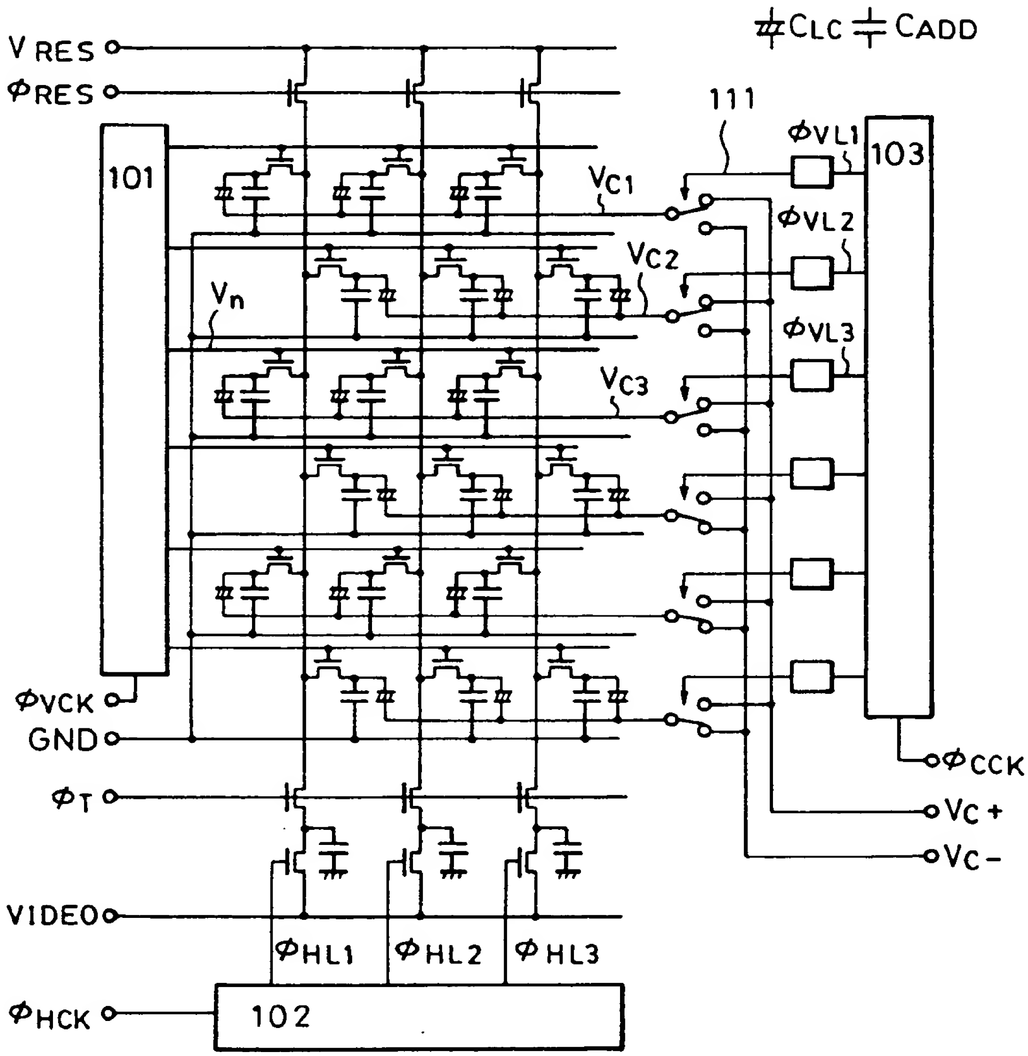
CLC CADD
VRES
ΦRES
111
ΦVL1
103
101
VC1
ΦVL2
VC2
Vn
ΦVL3
VC3
ΦVCK
GND
ΦCCK
ΦT
VC+
VC−
VIDEO
ΦHL1
ΦHL2
ΦHL3
ΦHCK
102

FIG. 5

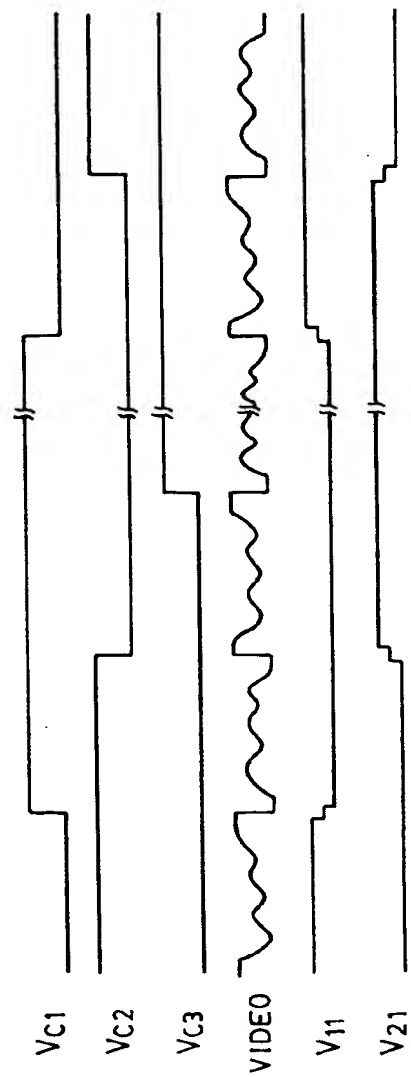

FIG. 6

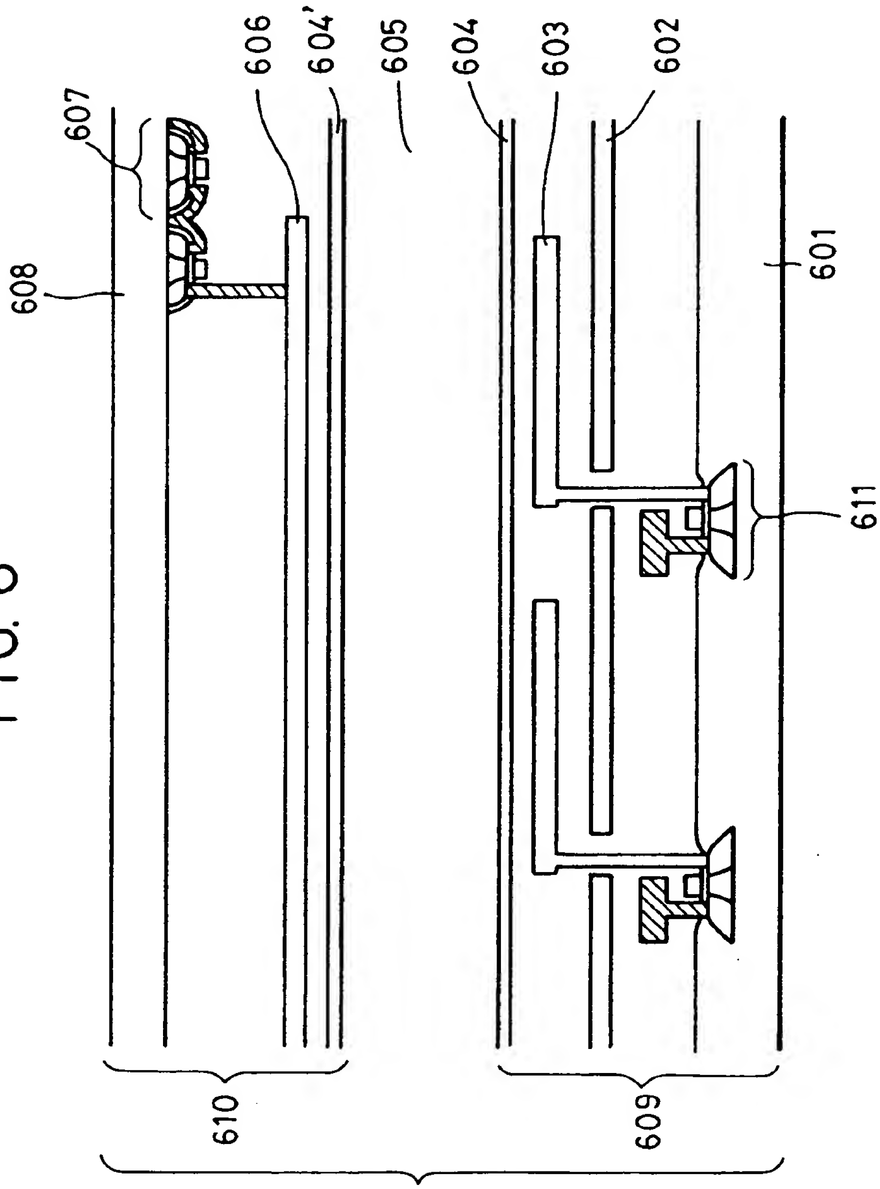

FIG. 7(a)

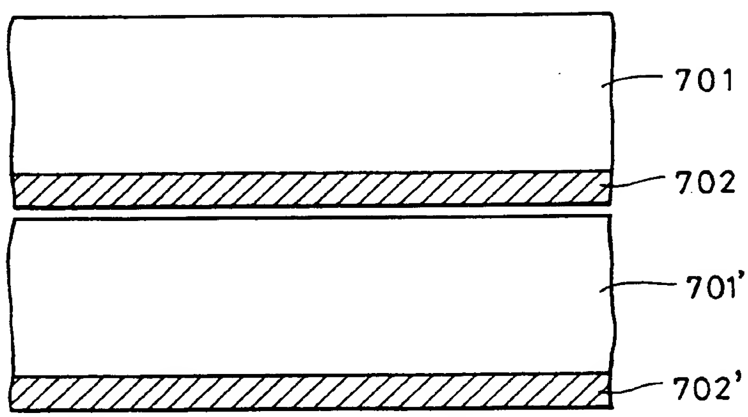

FIG. 7(b)

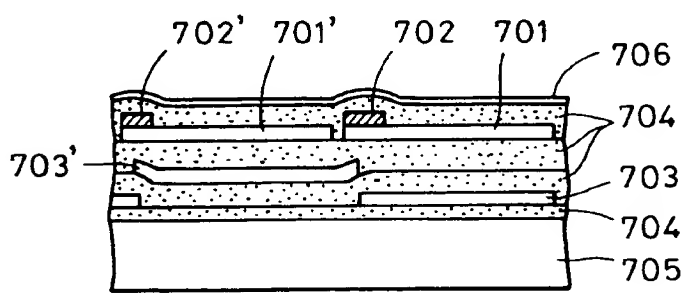

FIG. 8(a)

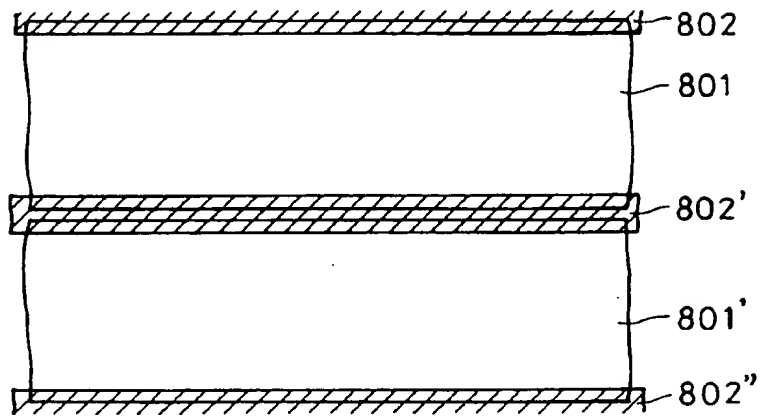

FIG. 8(b)